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Urea and nano-nitrogen fertigation and foliar application of nano-boron and nano-molybdenum on water use efficiency, agronomic efficiency and elements use efficiency by potato plants (*Solanum tuberosum.* l)

Hayyawi WA Al-juthery[1], Estabraq Hilal Obaid Al-Maamouri[2*]
[1-2] University of Al- Qadiseyah, Iraq

Abstract
Investigating the effect of fertigation of urea and nano-nitrogen and the foliar application nano-boron and nano-molybdenum on water use efficiency, agronomic efficiency and elements use efficiency by Potato Plants (*Solanum tuberosum*. L) [*Rivera – A*], A field experiment was conducted during autumn season 2018 in a private farm located in Al-Taliah area - Babylon governorate. The experiment consisted of 12 treatments: separated fertigation of nano-nitrogen (25% N) and urea (46% N), separated foliar application of nano molybdenum (5% Mo), Nano 9 (9% B), nano binary combinations treatments of nano (Mo+B) and (U+Mo), (U+B), Nano (N +Mo), Nano (N+B), and tricombinations treatment of (U+Mo+B), Nano (N+Mo+B) in addition to control treatment. This field trial was conducted in accordance with the (RCBD) design and one way simple experiment with three replicates. The fertilizers were applied at levels of (40) liters h^{-1} of nano-N-fertilizer (25% N) and (300) kg h^{-1} urea fertilizer (46% N) four times. The solutions were sprayed early in the morning after (40) days of planting four times with periods of two weeks from an application and another and as recommended by (1) kg nano fertilizer of B.h^{-1} and (500)g nano fertilizer of Mo h^{-1}. (NUE) varied according to its source Nano nitrogen or urea, (MoUE) and (BUE) according to its combinations. Efficiency of NUE (90.6, 92.9, 94.48 and 96.7) % for nano fertigation and foliar application treatments (N, N + Mo, N + B and N + Mo + B), respectively. NUE for urea fertilizer was (40.29, 42.05, 45.26 and 50.52) for fertigation and foliar application treatments (U, U + Mo, U + B and U + Mo + B), respectively. The efficiency of nano molybdenum use valued (80, 84, 88, 92, 96, 96.7) % for fertigation and and foliar application of the treatments of (Mo, Mo + B, U + Mo, U + Mo + B, N + Mo and N + Mo + B), respectively. The efficiency of the use of nano-boron (78.88, 81.11, 85.55, 89.22, 91.11 and 97.77) % for fertigation and foliar application of the treatments of (B, Mo + B, U + B, U + Mo+ B, NB and N+ Mo+ B) sequentially. The single application treatment of nano (Mo) fertilizer resulted in the highest field efficiency (2747.3) kg^{-1}.

Keywords: potato, fertigation, foliar application, nano-fertilizer, NUE

Introduction

Nano fertilizers are more useful than conventional fertilizers. They have the ability three times as effective for nutrients to reduce chemical fertilizer requirements and make crops resistant to drought and disease and less dangerous to the environment. They easily absorbed by plants because of their high surface area to volume ratio (Al-Juthery, *et al*., 2018) [7]. The size and morphological form of nanoparticles are also powerful factors that determine the level of bio-access of plants from the soil.

Nanoparticles may not be active to be immediately absorbed by plants. There may even be a series of reactions ranging from oxidation and recombination to the proper supply of micronutrients to plants. Since the nutrients in the nanoscale, enhancing the composition of the plant with nanotechnology seems to be an interesting option. Not only do plants grow but they also accumulate such nutrients, which fill the nutrient deficiency gap. Furthermore, nano-fertilizers can be designed in a way that addresses the deficiency of certain nutrients in plants (AL-Taey and AL-Musawi, 2019) [9]. This is possible because the atoms on the surfaces of nanomaterials can be structured to obtain different properties. Li *et al.* (2016) reported that anionic minerals and nanoparticles are largely absorbed by porous materials, or soil, making them highly readily available as nutrients or even contaminants when they are not desirable. Which is environmentally friendly and can reduce nutrient loss, with an overall increase in crop and food production, Kamran *et al* (2016) [33]. In short, nano fertilizers may be the best that can happen in the agricultural revolution, because they have potential to promote soil fertility and nutrient sustainability, Prasad *et al* (2017) [56]; Tripathi *et al* (2017) [79]. Nano fertilizers are modified fertilizers manufactured by chemical, physical or biological methods using nanotechnology to improve their traits and composition, which can enhance crop productivity, Singh *et al* (2017); Elemike *et al* (2019) [16].

Fertigation is the process by which fertilizers are used through irrigation water. By definition, fertigation is an accurate application of water-soluble fertilizers through sprinkler and drip irrigation systems, Billsegars (2003) [12].

Through this, it is possible to achieve significant savings of fertilizers when using fertilizers with water through the drip irrigation system. Regardless of the increase in yield, there were water savings compared to methods of irrigation. It helps achieve high fertilizer and water use efficiency. Drip fertilization can reduce crop yield degradation due to high groundwater levels and heavy rainfall. Nutrient supply is allowed directly into the root zone during critical periods of crop application for nutrients, Kozhushka *et al*. (1994) [38]; Drip fertilizer also provides an effective system for fertilizer delivery, reduces the overall fertilizer application rate and reduces adverse environmental impact, Hartz *et al* (1996) [22].

Fertility and the resultant harvest efficiency because of supplement irregularity in the soil, which has been perceived as a standout amongst the most imperative factors that limit crop yield (AL-Taey, *et al*., 2018) [7]

Foliar Nutrition means the application of the nutrients needed by the plant by spraying their solutions on the vegetative mass within certain concentrations and at the right time. Therefore, the plants can absorb it through the stomata of the leaf or through the cell walls and membranes to participate in the vital plant processes. This increases the vegetative mass and qualitative qualities are suitable to avoid conditions that reduce the availability of plant nutrients in the soil, Jamal, *et al* (2007) [31].

Nitrogen (N) is one of the most important elements in plants after carbon, hydrogen, and oxygen because of its main role in the production of chlorophyll which is essential for photosynthesis. Also, nitrogen is part of various enzymatic proteins that stimulate and regulate plant development processes, Sinfield *et al* (2010) [70]. Hussein M. Khaeim (2019) [27] Furthermore, nitrogen contributes to the generation of safe chemical components against parasites and plant diseases, Hoffland *et al* (2000) [26]. Finally, crop yield and biomass are strongly influenced by nitrogen fertilization, Tremblay *et al* (2011). Plants absorb nitrogen as a mineral nutrient primarily from the soil, and in the form of ammonium (NH_4^+) and nitrates (NO_3^-), Taiz and Zeiger (2010) [77].

Molybdenum is a basic micronutrient. The availability of Mo in soil depends on several factors such as high oxide concentrations, pH soil reaction and the presence of organic compounds in soil components, Brent (2005) [13]. Molybdenum presents in various complexes such as molybdenite (MoS_2), wulfenite (PbMoO4) and ferrimolybdenite [Fe_2 (MoO4)]. This solid mineral increases Mo in the soil through the weathering process associated with the oxidation and reduction processes in the soil. However, molybdenum is more soluble in alkaline soils and easily accessible by plants in the form of MoO^{-4}, Fageria (2013) [18]. In acid soils, molybdenum availability decreases with increasing anion adsorption to soil oxides, Reddy *et al* (1997) [59]. Plants need molybdenum in a small amount of (12 to 32) $g.ha^{-1}$ for physiological function, Singh (2008). Mo effect on plants is similar to other essential nutrients. Critical and toxicity deficiency levels vary from (0.1 to 1) $mg.kg^{-1}$ depending on the plant species and plant parts, Marschner (1995) [45].

Boron is a non-mineral micronutrient that is necessary for the natural growth and development of the plant. Its functions are to strengthen cell walls and development, fruit and seed development, sugar transfer, hormone development, membrane functions, RNA synthesis, cell division and respiration, and indole-acetic acid (IAA) synthesis. Moreover, it is necessary for other plant physiological functions such as carbohydrates, protein metabolism, and metabolism of indole acetic acid, cell wall synthesis, and phenol synthesis, Goldbach *et al* (2001) [19]. Boron is metallic in a wide range of soil pH reaction, Epstein and Arnold (2005) [17]. Its concentration ranges are from (20 to 200) $mg.Bo.kg^{-1}$ and the concentration of the available boron are varies with different soils, Mengel and Kirkby (1987) [47]; Khaeim, H.M. (2013) [27].

The potato, *Solanum tuberosum* L., which belongs to the Solanaceae family, is one of the most important vegetables and food crops in terms of nutritional importance and tops the list of tuber crops. It ranks fourth as a strategic and economic crop after wheat, rice, and maize, Taha, (2007) [76]; Karam *et al* (2009) [35], Tabrizi *et al* (2011) [75], Kandil *et al* (2011) [34]. It is a major crop in the diet of the entire world's population and is also used as animal feed, Eleiwa *et al* (2012) [15]. Potatoes are also an energy-rich food source of proteins, carbohydrates, starch, major amino acids and minerals important for human nutrition, Haynes *et al* (2012) [23]. Therefore, this study was aimed to investigate the effect fertigation of urea and nano-nitrogen and the foliar spray of nano-molybdenum and nano-boron in fresh tubers yield, Nutrients UE, AE and WUE of potato.

Materials and Methods

The study was carried out in a private farm located in Taliaa – Babylon governorate during autumn season 2018 in silty clay loam soils of chemical and physical properties shown in Table (1). It aimed of this study the effect of urea and nano-nitrogen fertigation and foliar application of nano-molybdenum and nano-boron on potato growth and yield. The soil was prepared after plowing with a tipper plow and was well graded by the rotary plow. NPK fertilizer of (18:48:0) was applied to the field right before planting (200) $kg.h^{-1}$. The experiment consisted of 12 harmonic treatments, Table (2). Planting lines were made at a distance of (75) cm in between. The experimental treatments were distributed and divided into experimental units of (3)m length, (2.25)m^2 area, RCBD design with three replications was used in this study. The experiment included 12 consensual treatments for the fertigation of urea fertilizers and nano-nitrogen fertilizer and foliar application of boron and molybdenum nano-fertilizers.

Potato tubers, (*Solanum tuberosum* L.) [*Riviera*-A], were planted on September 20^{th,} 2018. The used potato tubers were produced from the previous spring and stored at a temperature of (4°) C in cold stores. Outwardly healthy tubers were selected after transplanting and (0.2) m were left between one tub to another. The planting process was carried out by opening a hole with a depth of (0.10) m from the top of the line and along the line. The hoeing process was manual as needed to get rid of the bush growing with the crop. After 40 days of planting, nitrogen fertilizer of both urea and nano-nitrogen was applied four times (10, 20, 30 and 40) % for each time of the total amount of fertilizer to be applied (300) kg conventional nitrogen fertilizer (urea) kg h^{-1} and applied (40) Liters h^{-1} of Nano-N-fertilizer, Nano boron (9) % and Mo (5). After the equalization the weights to balance the same concentrations of nano-fertilizers in addition to the treatment comparison of spraying with water only were applied. All treatments were sprayed early in the morning four times with concentrations of (10, 20, 30 and 40) % of the total fertilizers amount for the first, second, third and fourth times, respectively, as recommended by (1) kg h^{-1} nano-boron and (500) g (1/2 kg) h^{-1} nano-molybdenum is compatible with the stages of crop growth, and the duration of a week between an application and the other.

Irrigation was done from a GR type drip irrigation system made for this purpose from the water source of Diwaniyah River with Ec (1.2) dS m^{-1}, using drip lines with a pressure regulator. Drip lines are placed on each top of the line with dots (the distance between the drips is 20 cm), with a discharge rate of (1.20) liters hour^{-1} for the dotted and (90.9) % distribution uniformity efficiency (Al-Juthery, 2011) [4]. Nitrogen fertilizers of both nano-fertilizer and conventional (urea) were applied by the fertigation drip irrigation system. After the plants reached maturity, the tubers were harvested on the 10th of January 2019 after harvesting the vegetative parts. The absorbed quantity of N, Mo, and B in the vegetatable parts was calculated according to the following equation:

Uptake amount of element (kg h^{-1}) = concentration of element in dry plant part (%) × dry matter product (kg)

Nutrient Use Efficiency (%) or uptake or recovery efficiency of each component estimated according to Yaduvanshi (1984) [83]:

Element use efficiency (%) = uptake of fertilizer treatment– uptake of the control treatment/quantity of applied element × 100.

Fertilizer productivity or agronomic efficiency (AE): kg of yield obtained per kg of fertilizer (Ali, 2011) [3], which was estimated from the following equation:

Fertilizer productivity = (production for fertilizer treatment - production of comparison treatment/quantity of applied fertilizer)

Moisture content measurements and moisture description curve: The percentage of humidity at different tensions was calculated using Pressure Membrane, Richards (1954) [60].

Water use efficiency (WUE): (kg obtained per m^3) was calculated according to the following formula, Hillel (2008) [25]:

Water Use Efficiency = production kg.$^{-1}$ for any treatment / applied quantity of water m^3

Soft tubers yield (Meg ha^{-1}): After maturity of potato crop the vegetatable yield and the total fresh tubers yield were calculated on the basis of the plants of the experimental unit.

Soft tuber yield (Meg ha^{-1}) = Total yield of experimental units × number of experimental units per hectare.

Data were analyzed statistically according to the method of analysis of variance and the significant differences between the treatments according to the design of (RCBD) at the level of significance (0.05) according to Duncan test, Sahuki and Wahib (1990) [62]. Genstat 2012 was also used in the statistical analysis process.

Table 1: Chemical and physical properties of field soil.

property	Value	Estimated Methods
Particle size distribution (gm kg^{-1}soil)		
Clay	120	Kilmer and Alexander, 1949 [37]
Silt	580	
Sand	300	
Texture	Silt clay loam	
CEC C mol$^+$ kg^{-1}Soil	26.3	Salim and Ali, 2017 [3]
OM gm kg^{-1}Soil	16.0	
Calcite gm kg^{-1}Soil	217	
pH	7.6	
EC(1:1) (dS m^{-1})	2.1	
Available macronutrients (mg kg^{-1}soil)		
N	27	Salim and Ali, 2017 [3]
P	14	Landon, 1984 [41]
K	290	
Mo	0,6	Salim and Ali, 2017 [3]
B	0.8	
Bulk density Mg m^{-3}	1.4	Landon, 1984 [41]

Table 2: The experiment treatments and their quantities of fertilizer applications

Tr. No	Fertilizers percentages Treatments	10% of the total fertilizer amount per ha		20% of the total fertilizer amount per ha		30% of the total fertilizer amount per ha		40% of the total fertilizer amount per ha	
		kg or L ha^{-1}	g 100L^{-1}	Fert*	Fo**	Fert	Fo	Fert	Fo
T_1	Control spray water only	0	0	0	0	0	0	0	0
T_2	Foliar application of nano Mo 5 *%*	0	12.5	0	25	0	37.5	0	50
T_3	Foliar application of nano B 9 *%*	0	25	0	50	0	75	0	100
T_4	Foliar application of nano (Mo+B)	0	12.5+25	0	25+50	0	75+37.5	0	100+50
T_5	Fertigation of Urea + Foliar application of water	30	0	60	0	90	0	120	0
T_6	Fertigation of Urea + Foliar application of nano Mo	30	12.5	60	25	90	37.5	120	50
T_7	Fertigation of Urea + Foliar application of nano B	30	25	60	50	90	75	120	100
T_8	Fertigation of Urea + Foliar application of nano (Mo+ B)	30	12.5+25	60	25+50	90	75+37.5	120	100+50
T_9	Fertigation of nano N + Foliar application of water	4	0	8	0	12	0	16	0
T_{10}	Fertigation of nano N + Foliar application of nano Mo	4	12.5	8	25	12	37.5	16	50
T_{11}	Fertigation of nano N + Foliar application of nano B	4	25	8	50	12	75	16	100
T_{12}	Fertigation of nano N + Foliar application of nano (Mo+B)	4	12.5+25	8	25+50	12	75+37.5	16	100+50

*Fertigation **Foliar application

Results

Soft tubers yield (Meg ha^{-1})

The highest soft tuber yield was resulted in the treatment of (N + Mo + B) of (37.53) Meg ha^{-1}, significantly increase compared to all treatments including the tricombination of (U+ Mo+B) that valued (33.12) meg ha^{-1}. The binary combinations treatment of nano (N+B) resulted in the highest soft tubers yield of (35.77) Meg ha^{-1}, which is significantly higher than the other binary treatments (U+B) (U+Mo) and (Mo+B), which resulted in (32.27 and 30.91 and 25.03) meg ha^{-1}, respectively. The single treatment of Nano N, U, Nano B, and Nano Mo resulted in yield values of (33.02, 30.43, 23.52 and 22.96) Meg ha^{-1}, respectively, were all increased compared to the control treatment of (21.58) Meg ha^{-1}.

Water Use Efficiency (WUE) kg m^{-3}:

The results of the effect of urea and nano-nitrogen fertilizer fertigation and sprayed of B and Mo nano-fertilizers indicate significant discrepancy in water use efficiency or water productivity shown in Table (3). The tricombination of (N+Mo+B) resulted in the highest increase in water use efficiency of (20.62) kg m^{-3}. It made significantly increased as compared to all treatments, including control treatment (spray water only), which had the least water use efficiency value of (11.86) kg m^{-3}. The treatment of tricombination (U+Mo+B) valued (18.20) kg m^{-3}. The treatments of dual combinations of (N+B), (Mo+N), (U+ B), U + Mo) resulted in values of WUE (19.65, 18.97, 17.73 and 16.98) kgm^{-3}, respectively.

Fertilizer productivity (field efficiency) (kg kg^{-1}) or Agronomic efficiency (AE)

Table (3) presents that the fertigation of U fertilizer and nano-N and spray of nano (molybdenum and boron) and their combinations affected on the agronomic efficiency. The fertilized urea and its combinations resulted in the least field efficiency value of (29.5, 31.0, 35.5 and 38.3) kg kg^{-1}for (urea, urea + molybdenum, urea + boron, and urea + boron + molybdenum), respectively without significant difference among them. The highest agronomic efficiency was achieved with a significant increase with individual sprayd of nano-Mo and nano-B and nano-B + nano-Mo, which amounted to (2747.3, 1934 and 2299.1) kg kg^{-1}, respectively, without significant difference among them.

Element use efficiency (%)

Presents that the highest nutrient use efficiency of the elements resulted in the combined nano-fertilizers (NUE, MoUE, and BUE) (96.69, 98.00 and 97.68) %. The highest of UUE was at the tricombination treatment (U+Mo + B) (50.52%). The lowest NUE was achieved with the treatment of single nitrogen fertilizer was (90.55%). The lowest BUE was (79.70) % when treated as a single nano boron sprayed. The lowest of MoUE was achieved with the treatment of single molybdenum sprayed (74.73%) and the minimum UUE was obtained with the treatment of individual urea fertilizer (40.29%). NUE for (N+ Mo) and (N+B) resulted in valued of (92.88 and 94.47) % respectively. The UUE of the binary combination was with the treatments of (U+ Mo and U + B) (42.04 and 45.26) %, respectively table (3).

Table 3: Effect of fertigation of Urea and nano-nitrogen and spray of nano Mo, and B fertilizers on water use efficiency, agronomic efficiency and element use efficiency

Tr. No	Fresh tubers yield meg ha^{-1}	WUE kg m^{-3}	AE kg kg^{-1}	NUE %	UUE %	MoUE %	BUE %
T_1	21.583 i	11.86 h	0	0	0	0	0
T_2	22.967 h	12.61 g	2748.3a	0	0	80	0
T_3	23.517 h	12.92 g	1934.0a	0	0	0	78.88
T_4	25.032 g	13.75 f	2299.3a	0	0	84	81.11
T_5	30.437 f	16.72 e	29.48 b	0	40.298	0	0
T_6	30.912 f	16.98 e	31.04 b	0	42.05	88	0
T_7	32.278 e	17.73 d	35.49 b	0	45.260	0	85.55
T_8	33.029 de	18.20 d	38.26 b	0	50.529	92.0	89.22
T_9	34.016 cd	18.14 d	285.82 b	90.6	0	0	0
T_{10}	34.534 c	18.97 c	319.77 b	92.9	0	96. 0	0
T_{11}	35.770 b	19.65 b	346.02 b	94.48	0	0	91.11
T_{12}	37.525 a	20.62 a	384.14 b	96.7	0	96.40	97.77

Discussion

Researchers have shown that water management is a determining factor in potato production. It is possible that there will be increases in production through scheduled irrigation systems throughout the crop growth period, Panigrahi *et al* (2011) [53]. Nutrients can be managed optimally in dry and semi-arid areas by adopting a modern farming technique such as the use of a mixture of slow-release fertilizers with drip irrigation, Janmohammadi *et al* (2016) [32]. The method of drip irrigation is an effective method for the purpose of potato quality by achieving a significant increase in productivity. This is confirmed by Al-Juthary, (2011), Petr Elzner *et al*., (2018) [54] and Al-Shami, (2019) [67] when studying the effect of drip irrigation and nitrogen fertilization on potato yield. The reason for the drip irrigation method is due to the daily application of water, no water stress, and the consistent distribution of nutrients with water movement at the root zone, which encouraged the potato crop to grow well to give a better yield with a significant improvement in water use efficiency because there are no losses in water transfer and leakage to the area below. This is consistent with Ibragimov *et al*. (2007) [29], Richard *et al*. (2007) [61] and Nagaz *et al*. (2008).

Drip irrigation increases yields by up to (70) % of potato yields compared to other irrigation methods, Matovic *et al*., (2016) [46]. Drip irrigation and the efficiency of this method in the distribution and homogeneity and reduce wastages of nutrients, Hadithi *et al*., (2010) [20]. Fertigation was done through the application of mineral fertilizer with irrigation water. This method is highly efficient and encouraging yield results as pointed out by Shedeed *et al*. (2009) [68], Selim *et al*. (2009) [65] and Selim *et al*. (2010) [66]. The results showed that the lowest significant decrease in the AE was in the treatment of conventional nitrogen fertilizer (urea) compared with the highest AE achieved with the treatment of nano fertilizer, foliar application (molybdenum). This indicates the active role of nano fertilizers in spite of the small amount applied to the uptake efficiency, metabolism, and transport, which is reflected in stimulating growth and increase the yield. Characterization of nano-fertilizers, this is consistent with Liu and Lal (2014) [43] asserting that the use of nano-fertilizers as an alternative to conventional fertilizers with application methods with irrigation water can encourage and improve agronomic efficiency (AE). These results are in line with Kumar (2017) [39], where the highest field efficiency of the rice crop was achieved when treated with slow-release N-fertilizer. The nano-fertilizer increases the nutrient use efficiency, due to its slow release and the small size of its nanoparticles made it more sensitive by the plant, which led to its recent designation (Intelligent fertilizers) and its distinctive behavior made it be the most efficient in absorption, Qureshi *et al*., (2018) [57]; Al-juthery and Sahar, (2018) [7]. Increasing the production capacity in the unit area can be increased by following the correct scientific methods studied in all agricultural works, including knowledge (quality, quantity, date, and method of fertilizers applications)

It was observed that the Nitrogen U E was significantly increased compared to the urea nitrogen of fertigation. This is because the fertilizer applied through the drip irrigation system is the most effective. A good strategy to improve the of nutrients use efficiency in agricultural systems with the possibility of providing nutrients at a low and high frequency improves the availability of nutrients in the root zone easier and faster absorption, with no chance of washing, stabilizing, and nutrient availability in the root zone of fertilizer, reducing the risk of nutrient loss. Incrocci *et al*., (2017) [30]; Al-Shami, (2019) [67].

Fertigation, in general, helps significantly increase the nutrient use efficiency of the plant in terms of nutrient recovery, with significantly higher results up to 90% than in other fertilizer application methods (40-45)%, Agostini *et al*., (2010) [2]; Solaimalai *et al*., (2010) [74]. Naderi and Danesh-Shahraki, (2013) [50]; Monreal *et al*., (2015) [48] demonstrate the active importance of nano fertilizers in terms of increased nutrient use efficiency, higher yield and better quality, and reduced soil pollution. It is also known that the efficiency of the use of micro-fertilizers (MUE) is low (up to 5%) when applied to the ground. Therefore prefer to applied bribes on the leaves. Singh *et al*. (2017) emphasize that the size and composition of active nano-fertilizer components can improve nutrient use efficiency, due to their small particle size (1 to 100) nm and to their very high surface area. Conventional nitrogen fertilizers contain particles larger than (100) nm, which makes them difficult to be absorbed by the plant, leading to a decrease in the efficiency of the use of conventional nitrogen Wijesinghe and Weerasinghe, (2015) [80] also confirmed Rameshaia, (2015) [58].

The application of slow-release nitrogenous fertilizers increases the efficiency of nutrient use by 3 times, as well as provides stress tolerance regardless of the type of crop. Also, the method of freeing nutrients from nano fertilizers leads to the plant's absorption of the whole available quantity of nutrients from the applied fertilizers instead of the minimum absorption. Nanoparticles have a larger surface area can fit many molecules, thus obtaining the largest amount to suit the needs of the plant, Naderil, and Danesh, (2013) [50]. Fertilizer efficiency remains low, especially for nutrients applied in high doses such as nitrogen. This condition is not limited to one element but to other nutrients found in soil that are essential for plant growth, Pilbeam (2015) [55]. The results are consistent with Naderi and Danesh-Shahraki, 2013 [50] and Monreal *et al*., 2015 [48]. These studies have demonstrated the importance of effective nano-fertilizer in terms of increased nutrient use efficiency, higher yield, and better quality, and reduced soil pollution. It is also known that the fertilizers use efficiency of microelements (MUE) is low (less than 5%) when applied to crops on the ground, AL- juthery and Saadoun (2018) [7], a significant improvement in the efficiency of the use of the element with foliar application of the fertilizers of nanoparticles such as iron, zinc, copper and manganese on the plant compared to traditional fertilizers.

The significant increase resulted by the soft tubers yield when nitrogen fertilization and foliar application with micro-nano-fertilizers (boron + molybdenum) due to the availability of the nitrogen element in the soil solution and its slow release to suit the growth of the plant so that the plant absorption for a longer period and not lost by washing and volatilization. As a result, the increased amounts of this element absorbed by the roots of plants. Nitrogen is characterized by its active role in the various metabolic processes of the plant life. It has a very important role in the growth of the plant and in general. The use of nitrogen increases the process of growth and productivity as well as the quality of crops, Kumar *et al*., (2014) [39]. These results are consistent with those obtained by, Moosapoor *et al*., (2013) [49], who noted that foliar fertilization with molybdenum and boron nano-fertilizers plays an important role in photosynthesis, resulting in increased leaf area and finally increased yield. It is also consistent with what Hopkins *et al*. (2007) and Singh *et al*. (2013) found when increased boron foliar application levels of potato plant increased potato tuber.

The small particles of nano fertilizers and their high surface area make them able to penetrate rapidly into plant tissues. This stimulates the action of plant hormones within the plant that promote the growth of secondary roots, which is reflected in growth and production, Barandozi *et al*., (2014). The presence of these elements side by side works to reduce stomatal resistance and increase stomatal conductivity, which provides the plant with enough carbon dioxide and water to continue photosynthesis and withdraw nutrients from the soil leading to an increase in yield, Yadegari, (2013). The behavior of nano- fertilizers once they enter the plant is related to protein carriers such as Aquaporin and Endocytosis. This leads to the formation of new openings that penetrate cell walls. It then stimulates water absorption and promotes plant growth and production, Schwab *et al*., (2015). These results are consistent with those obtained by Abyaneh and Maryam, (2014). The highest yield of potato soft tubers was achieved with an increase of (38) % using nitrogen fertilizers.

The micronutrients applied to the vegetative mass results are consistent with those obtained by Moosapoor *et al*. (2013) [49], who noted that fertilization by foliar spraying with nano-fertilizers has an important role in stimulating photosynthesis. This results in an increase in the leaves area and thus an increase in photosynthesis and an increase in the yield. These results are consistent with what Dongre *et al*. [14] (2000) found when foliar-applied boron on plant leaves by (0.25) % yielded in a significant increase in productivity, as well as Naresh (2002) [23] and Yadav *et al*. (2006) [71], as well as al-Tafi *et al*. (2009). Spray the tomato plant with boron. In addition to Manjunath *et al*., (2017) [44] as well as Haleema *et al*., (2018) [21].

Conclusions

It is possible to conclude that good potato productivity can be achieved through the use of nano fertilizers, whether by fertigation or foliar application compared to urea fertilizer with good irrigation management using drip irrigation method as well as high agronomic efficiency (AE), high element use efficiency (EUE) and high water use efficiency (WUE).

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